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ABSTRACT

Every child who enters a school system brings a different level of language mastery with which to recognize and express a different background of experience. This study examined the development of mathematical understanding and tested the efficacy of direct teaching to the target concepts. Two very similar districts in rural Idaho were selected. Three intact classes in each district, chosen at random, were given the Boehm Test of Basic Concepts. From the result of the pretest, the least known concepts were selected as target concepts. The concepts were discussed at inservice sessions for the experimental teachers twice a week for 10 weeks. After each session each teacher developed plans and taught each concept. The percentage gains between pretest and posttest indicated that the experimental group did better than the control group on 7 out of 13 concepts. Four concepts for which the experimental group did not make marked gains are discussed. The three most important elements of the experiment were considered to be: (1) questioning about what the children already know; (2) raising the teacher's consciousness regarding the target concepts; and (3) providing materials and pooling teachers' ideas suggested by the materials. (YP)

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MATH RELATED LANGUAGE-CONCEPTS:
EFFECTIVENESS OF DIRECT INSTRUCTION IN
RAISING THE LEVEL OF MASTERY OF BEGINNING
FIRST GRADERS IN RURAL WESTERN IDAHO

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In a recent report of the National Science Board Commission of Pre-College Education in Mathematics, Science and Technology the teaching of mathematics at all levels was identified as an area of major concern in the United States. Top priority must be placed on providing increased and more effective instruction in mathematics in grades K-6 (1983).

Idaho is no exception in this situation, and individual school districts have begun to focus attention on testing results to identify the weaknesses and to seek means to strengthen their programs. In a southwest Idaho school district, it was noticed that by the end of the primary years class averages were below the national norm in mathematics and generally remained that way through the ensuing years of education. It is apparent, then, that while students' performance in the early grades might be adequate, there was not a strong enough foundation to support the development of more complex mathematical concepts in the intermediate years.

While obviously many areas are integrally involved, the most frequent complaint of the teachers about student performance has been, "They don't understand the concepts." Before a definitive remedy can be applied it is necessary in dealing with children of this age to identify if there is a deficiency in concept development, in language development dealing with the concepts, or in both.

The problem, then, which this research addressed can be summarized in the question:

Can a stronger foundation in primary mathematics be attained through an early intervention which would establish mastery of identified math-related language concepts?

Areas of research related to this problem are the word acquisition and concept development of five, six and seven year olds, and the importance of basic concepts in the development of mathematical understanding. Ann Boehm did the groundwork in connecting these areas in her dissertation (1967) which resulted in the Boehm Test of Basic Concepts (1971).

Additional impetus was provided at the beginning of this decade by the renewed emphasis on mathematical concepts at every level. (National Council of Teachers of Mathematics, 1980, 1981). Finally, the report Educating Americans For the 21st Century (1983) delineated clear goals for all levels of mathematics education, and demanded that concept development be the foundation of all mathematics programs. It is within this context that this research study was developed.

This preliminary study was intended to provide data relating to the following questions:

►What is the level of math-related language concepts of a child from a rural background such as that of Payette or Weiser when he enters first grade?

►Are the students ready for beginning mathematics?

►Can their readiness be improved through direct teaching of quantitative concepts?

The answers to these questions have several implications for education in Idaho. They identify the importance of kindergarten in establishing a math-related language concept base; they would identify curriculum needs at the primary level for comparable school districts; they indicate the efficacy of specific in-service work as defined in the procedure.

Every child who enters a school system comes from a different background of experience and thus starts out with a different body of knowledge and set of understandings. In the same view every child brings with him/her a different level of language mastery with which to recognize and express this background of experience. In a state such as Idaho where kindergarten is not required, it is in the first grade that children first come up against a determined body of content to be mastered. First grade teachers must cope with the problem of individual differences in knowledge of fundamental concepts. There are at least three options available for teachers in dealing with these differences: 1) They can assume that such knowledge is common to the necessary extent among all students; 2) They can provide a minimum of instruction to each entering child or; 3) They can assume that the child will arrive at the necessary understanding within the context of the regular teaching without special effort. The most common practice is a combination of 1) and 3).

This research has attempted to test the efficacy and practicality of option 2, through use of the concepts incorporated in the Boehm Test of Basic Concepts. These concepts were selected because they 1) occurred in considerable frequency in primary grade curriculum materials, especially mathematics; 2) were seldom if ever explicitly defined, or were defined in their simple forms but subsequently used in more complex forms without adequate transitions, and 3) represented relatively abstract basic concepts or ideas. In addition, forty-five of the fifty words included in the test were identified as quantitative in nature.

Take, for example, the concept nearest - an ordinary word in adult vocabulary but also an indefinite semi-abstract quantitative term often confusing to young children of limited experiential language backgrounds. Characteristic teacher uses might be the following:

- ▶ "Sit in the nearest chair."
- ▶ "Tell me what time it is to the nearest hour."
- ▶ "What number is the small hand nearest?"
- ▶ "Is it nearer to breakfast or to lunch?"
- ▶ "Who lives nearer to school than John?"
- ▶ "Are two dimes or three nickels nearer to the answer?"

Accurate interpretation would necessitate a child being able to recognize the implied relationship. If the relationship does not make sense in the context of experience, the child has lost the meaning. Frequently, a child is still struggling with the various meanings of the term when the teacher has already moved on to ideas of greater complexity.

This study was intended to provide data on what the average child understands and how teachers can extend that understanding before moving too far into the mathematics program. At the same time all efforts were made to keep the research within such parameters that the procedures used would be appropriate in any primary school setting.

DESIGN OF THE STUDY

The design of the study was the following. Two districts in rural Idaho were selected which were very similar in size, ethno-socio-economic conditions, and school structure. Each had five first grades in their primary schools, and since kindergarten is not required in Idaho, first graders were selected as the target groups. Three intact classes in each district, chosen at random, were given the entire Boehm Test of Basic Concepts (1971 edition, Form A) during the first week of the school year. Tests were administered by the researchers and a trained graduate assistant. The pretest allowed the identification of these concepts already mastered as well as those least known concepts which would be used as target concepts. It also established a baseline from which the percent gain could be measured for both the control and the experimental groups. This design allowed for a check of the reactive effect of pretesting by comparison between the post-tests of this group and the post-test only groups. No significant difference was noted.

The control group consisted of 42 boys and 41 girls (n=83) whose average age was 7-6 (range 6-10 to 8-7). Approximately 15% were Hispanic and 12% had not attended kindergarten. The experimental group consisted of 38 boys and 46 girls (n=84) whose average age was 7-7 (range 6-9 to 9-6). Twenty percent were Hispanic and approximately 25% had not attended kindergarten. No attempt was made to identify within the Hispanic groups how many were migrant, nor how many were non-English speaking or bilingual.

The teachers involved in the study were the five regular first grade teachers of the experimental group. They had been teaching an average of 16.6 years (range 10-23) with an average of 11.3 years in that district (range 6-21). Three weeks after the Boehm Test of Basic Concepts was administered, a sixth teacher was hired who was beginning her first year of teaching; her class was drawn from the overload in the other five classes and some of the students had been included in the pre-testing.

The tests were scored according to protocol and the least known concepts were selected as the target words. These were grouped for discussion at inservice sessions scheduled biweekly for ten weeks. One of the researchers met with all the teachers of the experimental group, bringing materials and suggestions as to how teachers might teach to these concepts. The teachers also brought appropriate materials and suggestions, and the one and a half hour sessions were informal sharing times typical of a group of teachers working toward a common goal. After each session each teacher was free to develop plans and teach each concept as she wished, spending as much time as she chose and reinforcing the application of the concept as opportunities arose. Teaching of the concepts were cumulative as the weeks progressed, the least known concepts receiving the most time for mastery. The teachers were asked to keep a notebook of the materials and results, and some samples of what they taught, and a record of the methods used. At the end of the ten weeks, all first grade students of the two districts were post-tested using Part II, Form B of the Boehm Test of Basic Concepts. (Since the pre-test had established that more than 30 of the 50 concepts were generally understood by at least 80% of the children, it was judged best to eliminate Part I of the post-test.) The results were then analyzed to determine the effectiveness of the intervention.

TABLE 1
AVERAGE PERCENT GAIN OF TARGET CONCEPTS

Target Concept	% Gain - Post Test over Pre Test			Time for Teaching
	Control	Experimental	Difference	
equal	27.8	53.2	25.4	10 weeks
least	27.6	41.9	14.3	10 weeks
pair	12.8	33.7	20.9	10 weeks
right	14.9	14.8	- 0.1	8 weeks
in order	12.0	2.9	- 9.1	8 weeks
left	22.0	8.3	-13.7	8 weeks
skip	11.3	16.4	5.1	6 weeks
always	9.2	33.0	23.8	6 weeks
forward	4.9	15.5	10.6	6 weeks
side	6.8	20.3	13.5	4 weeks
medium-sided	8.4	9.0	0.6	4 weeks
center	10.8	13.2	2.4	2 weeks
never	12.4	- 7.3	-19.7	2 weeks

The concept "third" was discarded because the post test item tested to a different concept.

In view of the relatively high mastery of some of the concepts by both groups, some error from regression is also assumed.

The results indicate that the experimental group made notable gains over the control group in seven concepts which clearly paralleled the emphasis of the teaching as reflected in the teachers notebooks. The study of those concepts in which the experimental group did not make marked gains is perhaps more important in light of the purpose of this study. The test were reviewed individually and the errors analyzed.

Right/left: In the test items, students were to mark the apple on the right (of four in a row); they marked the left in a row of three trees. About an equal number of boys and girls missed these, and it appeared clear that the errors resulted from a confusion between the two concepts. It was noted that with one exception, the teachers' notebooks held little reference to the teaching of these concepts in class, an indication that despite testing results teachers assumed the children already had a good understanding of these two words. This interpretation was reinforced by teachers' comments that "right/left is taught in kindergarten."

In order: For this concept, the children were to mark one of three choices. In each choice, four different-sized boxes were drawn in various vertical arrangements. Teachers' notebooks consistently showed or taught order as a left to right, horizontal progression. The children seemed not able to make the transference.

Medium-sized: For this concept, illustrations were of a medium-sized butterfly and a small butterfly. Only nine boys missed this item in contrast to 21 girls; the girls who missed it chose instead the large butterfly in the middle, indicating the confusion between middle (space) and medium-sized (quantity).

Never: The errors relating to this concept seemed to arise mostly from a cultural - experiential confusion. Students were to select and mark an item which "a child should never wear"; the choices were a lamp, a wristwatch and a shoe. Children missing this item consistently chose the wristwatch. In response to informal questioning many students indicated that they had played "dress up" with lamp shades, but as primary students in the rural setting, they never wore a wristwatch. This was also a concept which was allowed the least amount of time for clarification of the meaning.

Third: The concept third as discussed by the teachers and taught in turn to the students, was the simple serial concept first, second, third. . . . As the item was worded on the post-test, students were asked to mark "the third house from the store in a row of four." It was judged that this term be discarded as it did not really test the concept as it was interpreted.

An analysis of the errors of the two subgroups showed that the children who had not attended kindergarten had a much higher percentage of errors on each target concept than the respective group average, and that the percentage of errors of the Hispanic group were often two or three fold that of the average.

In addition to the notebooks recording teaching practices during the study, teachers were asked to respond to a Likert-type survey in which they ranked the elements of the study which they felt were most helpful to them as teachers.

They unanimously placed three factors as most important:

1. Questioning their assumptions about what the children already knew;
2. Raising their consciousness regarding the target concepts so that they took advantage of more opportunities as they arose to reinforce the concepts;
3. Using materials provided by college instructors and pooling their own ideas suggested by these materials.

The importance of questioning the assumptions was reinforced in the written comments of the evaluation; this result was unexpected in view of the 100 years of teaching experience represented in the group. The teachers also ranked high (1.5 - 1.8 on a

scale where 1 is the highest) such factors as college instructors coming to the school regularly, working as a group toward a common identified goal, informal discussion on the concepts, and interest of the administration. They were again unanimous in designating that they had definitely enjoyed the experience and found the research aspect useful to them as professional educators.

CONCLUSIONS

The results of this study seem to indicate that these first grade students had considerable mastery of the identified quantitative concepts and fell within the lower limits when compared with their socio-economic counterparts on a national norm. The value of kindergarten is clearly evident in laying a foundation of math related language concepts for these children. Hispanic children with an English language deficit have the greatest need for direct intervention by their teachers.

The efficacy of direct teaching to the target concepts was evident, and this efficacy is a direct function of the teacher's ability to recognize the need, and willingness to incorporate such concepts frequently into the regular classroom activities. Recognition of the need on the teacher's part to challenge assumptions of what the children "already knew" or "had been taught" was an unexpected result of this study.

The results also suggested that informal classroom research by experienced teachers working together on a common problem could be a very effective form of inservice, especially when the problem is clearly identified, specific goals are set, and the teachers are supported by administrators and outside sources in seeking the solution.